CHARACTERIZATION OF A MAUNA KEA PALAGONITE USING TRANSMISSION ELECTRON MICROSCOPY; T.L. Roush (San Francisco State Univ. & NASA Ames) and D. Blake (NASA Ames)

Palagonitic soils from Mauna Kea, Hawaii represent some of the best visible and near-infrared spectral analogs for the bright soils and dust on Mars [1,2]. These soils represent weathering products of both gas and liquid interactions with basaltic glass, and as a result, they can lie anywhere along a continuum between strictly amorphous and highly crystalline end members. Recent studies using X-ray diffraction and Mossbauer spectroscopy indicate that similar palagonitic soils contain crystalline layer lattice silicates and nanophase hematite [3,4]. We studied a palagonite using Transmission Electron Microscopy (TEM) because this technique provides the ability to determine the elemental abundance, particle size distribution, and crystallinity of extremely fine-grained specimens. The palagonite selected for analysis was initially collected at several locations on the upper slopes of Mauna Kea, Hawaii. The finest grain size fraction was separated from the bulk sample by liquid particle suspension in methanol and its spectral properties have been presented elsewhere [5,6] along with a bulk chemical analysis [6].

In order to determine a particle size distribution several microphotographs were collected and the longest and shortest lengths of 610 grains were measured. These values were used to calculate the equivalent spherical particle diameter (d) via

$$d = \sqrt{ab} \tag{1}$$

where a is the longest length of the grain and b is the shortest. A weighted mean equivalent spherical particle diameter of $1.019 \pm 0.662 \mu$m was determined using

$$\overline{d} = \frac{\int n(d) d\pi \frac{d^2}{4} \partial d}{\int n(d) \pi \frac{d^2}{4} \partial d} \tag{2}$$

where $n(d)$ is the number of particles with diameter, d. The particle size distribution of this sample is illustrated in Figure 1.

Energy dispersive X-ray spectroscopy was used to determine the relative elemental abundances of 101 grains. The most abundant elements were Si, Al, O, Fe, and Ti and occasionally lesser amounts of Ca, Cr, Mg, and P were present in some samples. Grain-to-grain differences were highly variable with some grains exhibiting a reversal of the Al/Si ratio. Some grains appeared to be severly depleted in Si and Al but highly enriched in Fe and Ti. Three major classes were identified based on the most abundant element. Of the 101 grains 45 had silicon, 45 had aluminum, and 11 had iron as the most abundant element.

Electron diffraction can provide direct information regarding the crystalline nature of the grains. Based on the qualitative elemental analysis we selected a limited number of grains from each of the three major classes of materials. 4 of the 6 grains investigated with silicon most abundant did not yield a diffraction pattern. This implies that these materials are amorphous at an extremely fine scale. The diffraction patterns exhibited by the two other grains are consistent with smectite clays, although one grain appears to be a mixture of

minerals. 5 of the 6 grains sampled with aluminum most abundant did not yield a diffraction pattern, although two of these were probably too thick to transmit the electron beam. The diffraction pattern exhibited by the single grain currently remains to be identified. None of the 5 grains with iron as the most abundant element yielded a diffraction pattern. However, it appeared these grains were too opaque to transmit the electron beam and hence the crystalline nature of these grains remains uncertain.

In summary, the particle size of this palagonite sample was determined to have a diameter of 1.019± 0.662μm, indicating that this is the clay-size fraction of the bulk sample. The elemental abundances were highly variable on a grain-to-grain basis. A majority of the grains did not exhibit diffraction patterns, indicating the amorphous or poorly crystalline nature of the material. The diffraction patterns exhibited by some grains were consistent with diffraction patterns of layer lattice silicates, and more specifically smectite clays. Analysis is currently underway to characterize unidentified diffraction patterns and to identify the mineralogy of the iron-rich materials.

References: [1]Evans and Adams, PLPSC 10th, 1829; [2]Singer, JGR, 87, 10159; [3]Farrand and Singer, LPSC XXI, 347; [4]Morris *et al.*, JGR, 95, 14,427; [5]Singer and Roush, LPSC XIV, 708; [6]Roush, Univ. Hawaii PhD Dissertation, 130pp.

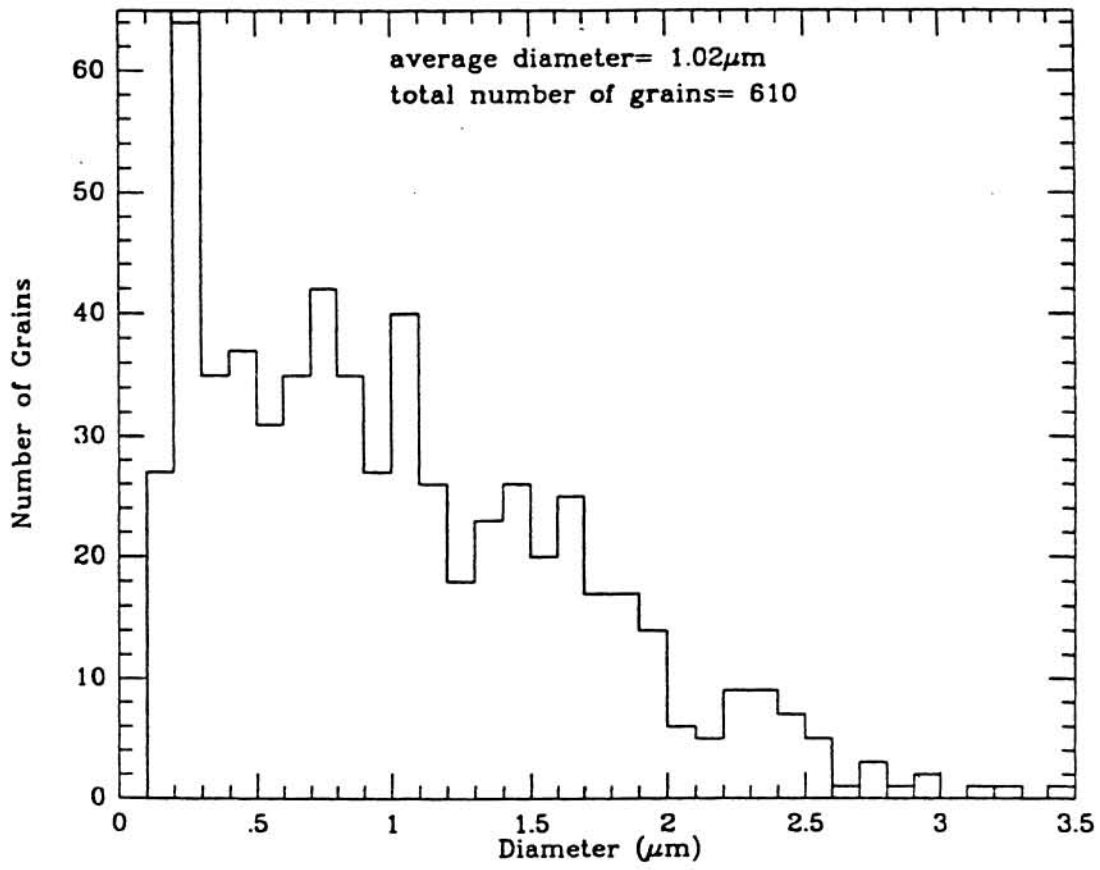

Figure 1. Histogram of equivalent spherical grain diameters.